इंटरनेट मानक

Disclosure to Promote the Right To Information

Whereas the Parliament of India has set out to provide a practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority, and whereas the attached publication of the Bureau of Indian Standards is of particular interest to the public, particularly disadvantaged communities and those engaged in the pursuit of education and knowledge, the attached public safety standard is made available to promote the timely dissemination of this information in an accurate manner to the public.

"जानने का अधिकार, जीने का अधिकार"
Mazdoor Kisan Shakti Sangathan
"The Right to Information, The Right to Live"

"पुराने को छोड नये के तरफ"
Jawaharlal Nehru
"Step Out From the Old to the New"

IS 13495 (1992): Design of sediment excluders - Guidelines [WRD 14: Water Conductor Systems]

"ज्ञान से एक नये भारत का निर्माण"
Satyanarayan Gangaram Pitroda
"Invent a New India Using Knowledge"

Act Number 22 of 2005
The Indian Parliament
RIGHT TO INFORMATION

Made Available By
Public.Resource.Org

"ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है"
Bhartṛhari—Nītiśatakam
"Knowledge is such a treasure which cannot be stolen"

BLANK PAGE

BRUTUM FULMEN

IGNORANTIA JURIS NON EXCUSAT

PROTECTED BY COPYRIGHT

IS 13495 : 1992
(Reaffirmed 2002)

भारतीय मानक

जलदार विलग्नक के डिजाइन — मार्गदर्शी सिद्धान्त

Indian Standard

DESIGN OF SEDIMENT EXCLUDERS — GUIDELINES

UDC 626·823·42

© BIS 1992

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

October 1992

Price Group 3

Barrages and Weirs Sectional Committee, RVD 20

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Barrages and Weirs Sectional Committee had been approved by the River Valley Division Council.

The sediment excluders are provided on the barrages or diversion weirs in the river pocket adjacent to the head regulator to minimize sediment entry into the canal water. On rivers, the excluders have to deal with alluvial material such as boulder, gravel sand or silt depending upon the parent bed material, that is, being transported by the river. The structural arrangement to reduce the amount of sediment passing into a canal head regulator is made by constructing a divide wall upstream so as to form a pocket in front of the canal intake. The wall divides the stream flow as it approaches the barrages and weir so that part of the flow is diverted to the sluiceway and part through spillway bays. The main function of the divide wall is to form a sluicing pocket to produce a ponding area of low velocity in which the sediment will deposit rather than enter the canal head works. The sediment thus deposited is to be either removed by sediment excluders or scoured out by turbulent flow through the pocket when the sluice gates are opened. Hydraulic model studies are undertaken to finalize various parameters such as divide wall length and orientation, gate regulation, etc. The scope of this guideline is restricted to furnish details of sediment excluders. Different types of excluders have been tried of various head works. Generally the excluders cover only a few bays of the undersluice but at certain head works they may cover more number of bays. The heavy sediment laden bottom layers flow through excluder tunnels towards the river stream downstream of undersluice leaving relatively sediment free top layers of water to flow through head regulator. The guideline for design criteria of sediment excluders have been enumerated in subsequent paragraphs.

All rivers in the northern and eastern parts of India which rises from the Himalayas, geologically young mountain, flow very fast in the upper reaches and carry with them heavy sediment load due to the comparatively soft hill formations. In the plains, their velocities are reduced due to the sudden changes with water surface slopes and the sediment load gets deposited. There is a low lying plain of alluvial deposits of Indus and Ganga rivers extending from Punjab to West Bengal, while in Assam there is a narrow stretch of lands through which the Brahmaputra and its tributaries flow. Thus, the sediment problem in these rivers is rather acute and includes boulders and gravels. The sediment concentration for these rivers varies from 2 000 ppm to 5 000 ppm by weight.

The southern rivers such as Godavari, Krishna, Cauvery and their tributaries, which rises from the Sahya mountains on the south of Vindhyas flow in a plateau formed by hard volcanic rocks over a terrain with a hard, high and strong banks on either side. As such, the sediment problem on these rivers is relatively simpler compared to northern Indian rivers.

Excessive sediment load can cause damage in a variety of ways which results in many serious problems such as (a) meandering of streams, (b) reduction of channel capacity, (c) silting up of canal, (d) damage to power units on hydel canals, (e) obstruction to navigation, (f) sediment bars of stream junctions, (g) silting up of reservoirs, (h) shoaling of harbours at river mouths, and (j) destroying the value of streams for pisciculture and recreational utility, etc.

In the following situations silt excluders are not required to be provided in river pockets:

a) If sediment trap, that is, flood control dams are available in upper reaches of weir/barrages and if tributaries bringing heavy sediment do not join in between reach,

b) If the sediment load coming in the river reach upstream of weir/barrage is only wash load and less than sediment carrying capacity of the canal,

c) Wherever proper regulation of the undersluices are possible so that the incoming sediment load in the pocket could be flushed completely, and

d) If sill of canal head regulator is 4 m or higher above the floor level of the pocket, decision on the omission may be taken after the assessment on the basis of model studies.

(*Continued on third cover*)

Indian Standard

DESIGN OF SEDIMENT EXCLUDERS — GUIDELINES

1 SCOPE

This standard covers criteria for design of sediment excluders and its flushings. The standard also includes a typical example of design of tunnel type sediment excluders using sediment transport concepts.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
1191 : 1971	Glossary of terms and symbols used in connection with the measurement of liquid flow with a free surface (*first revision*)
4410 (Part 2) : 1967	Glossary of terms relating to river valley projects: Part 2 Project planning
(Part 5) : 1982	Glossary of terms relating to river valley projects: Part 5 Canals (*first revision*)
10430 : 1982	Criteria for design of lined canals and guidelines for selection of type of lining

3 TERMINOLOGY

For the purpose of the standard, definitions for afflux, barrage, pond level, undersluices, divide walls, the outfall channel as given in IS 1191 : 1971, IS 4410 (Part 2) : 1967 and IS 4410 (Part 5) : 1982 shall apply.

4 DATA REQUIRED

The data required to carry out the design comprises: (a) stage discharge curves on the upstream and downstream of barrage site, (b) sediment size distribution curve and concentration in river, (c) river width, silt concentration and grade of sediment that can be permitted into the canal and slope at the site, (d) canal discharge, (e) dimensions of the barrage/weir head regulator and undersluice, (f) charge and grade of sediment in the river water coming into undersluice, (g) charge and grade of sediment that can be permitted to go into the canal.

In addition to above the requirement of data relating to the canal and barrage for design of sediment excluder is given in Annex A.

5 DESIGN CRITERIA FOR EXCLUDERS

5.1 Approach

The curvature of the river flow approaching the canal head regulator plays an effective role in the efficient working of an excluder and as such the locations of the mouths of the tunnels have to be decided, keeping in view the approach conditions. All possible river approach conditions are to be examined carefully while deciding the layout of excluder tunnels. The tunnels are located in front of the canal regulator and their alignment is kept parallel to the axis of the regulator as far as possible. Any deviation in their alignment, found necessary towards their tail ends, should be made on a smooth curve so that kinks are avoided.

5.2 Location of Tunnels

In case the excluder tunnels are staggered, the mouths of the two successive tunnels are so located that the zone of suction of the two adjacent tunnels adequately overlapped to avoid deposition between the mouths of the two tunnels. Each tunnel should have an opening only at the front, facing the approach. There should be no side openings.

5.3 Tunnels

5.3.1 Though circular or square tunnels are hydraulically more efficient, the experiments carried out show that the rectangular tunnels with width less than height are generally more effective for sediment transport. Generally, sediment excluder tunnels are rectangular in shape. The design of sediment excluders is tested in hydraulic model along with barrage design for visualizing hydraulic performance.

5.3.2 The excluder should normally span 25% of undersluice bays and shall be divided into an equal number of compartments or tunnels by vanes gradually converging so as to accelerate the escaping flow for delivering it to the outfall channel on downstream side of the barrage. The dimensions of tunnels should be such that they run full bore for the designed discharge.

5.3.3 *Spacing and Bellmouthing of Tunnels*

In excluders, tunnels at the inlet end should preferably be bellmouthed by decreasing head loss. Each tunnel has a certain zone of influence which extends upstream to a certain distance in straight direction as well as sideways up to some distance upstream. The two successive tunnels should be so placed that the zone of suction of the second starts before the zone of suction of the first tunnel ends. To create enough suction in tunnels and carry coarse material like gravel and boulders into the river, a minimum head of 0·9 to 1·2 m is necessary for satisfactory working. A smaller head suffices for finer material. The extent of zone of influence and efficiency are determined by models.

5.4 Escape Discharge Capacity

An excluder should be designed for minimum escape discharge which would secure maximum efficiency as well as satisfactory exclusion of sediment. This is essential to avoid unnecessarily turbulence and churning in the pocket which is caused by higher discharges in the pocket. Escape discharge may vary between 20 and 30% of the canal discharge.

5.5 The tunnel dimensions at the entry and the exit shall be so fixed as to ensure velocities that would carry the size of sediment to be removed. The section of the tunnel at the entry shall be so chosen that the velocity of flow at the intake is slightly higher than the velocity of bottom filaments of water upstream of the excluder. The section of tunnels up to their exit, where these end into the outfall channel shall be reduced gradually in such a way that there is an overall increase of 10 to 15% in velocity of emerging flow.

5.5.1 *Self Cleansing Velocity at the Tunnel Entry*

A velocity of 2 to 2·5 m/s is generally treated as self cleansing velocity inside the tunnels in alluvial reach and 3 to 4 m/s as self cleansing velocity inside tunnels in shingles and cobbles reach. For excluders, therefore, velocity more than self cleansing velocity may be assumed.

5.5.2 The velocity at the exit end of the tunnel may be worked out from the working head and throttling effected to attain velocity higher than 3·0 to 3·5 m/s at the exit in alluvial reach and 4 to 5 m s in shingles and cobbles reach. If the width of the tunnel is kept the same, throttling is done by lowering the underside level of the roof of tunnels in the case of excluders.

5.5.3 The tunnels normally run as a pressure conduits. However, there could be situations when flow with free surface may take place near the tail end of the tunnels. For such conditions, it should be ensured that there is no possibility of a hydraulic jump forming inside the tunnel.

5.5.4 Each tunnel must take the same discharge as others inspite of their unequal lengths. This is achieved by suitably adjusting the cross-section at intermediate points such that total loss of head in each tunnel is the same.

5.6 Roof Level of Tunnels

The roof of a sediment excluder should normally be located at the sill level of the canal.

5.7 Preferably the height of tunnels should be kept adequate to facilitate inspection and repair work. The tunnels shall be designed to run full bore to secure the maximum efficiency.

5.8 Control Structure

The discharge from sediment excluder is controlled by gated regulation at the downstream end of tunnels. The quantum of discharge to be run through sediment excluder and frequency of its operation would vary in different parts of the year depending on the permissible sediment load in the canal and the sediment load entering in the pocket. This is achieved by operating regulating gate as required. However, in practice, the gates are either fully opened or fully closed.

6 FLUSHING

6.1 During the period when sediment excluder is not required to function, it is desirable to operate the regulation gates frequently, for short periods to flush the tunnels. It is apprehended that if the silt excluder tunnels are closed for considerable time it may lead to the choking of the tunnel to the extent that it may become difficult to flush out hydraulically. Otherwise, the tunnels are likely to get choked and may require manual clearance which may be possible only during closure of the canal.

6.2 At times during the normal operation of the sediment excluder, the approach channel and/or tunnels may require flushing. This may be done by running the tunnels in rotation to achieve higher velocities.

6.3 Efficiency

The efficiency of an excluder is the percentage reduction in the quantity of sediment which would have entered the canal, had there been no such structure. For determining the efficiency of a sediment excluder, observations regarding the silt intensity may be taken as follows:

a) i) in the undersluice pocket upstream of the excluder tunnels, and
   ii) in the canal downstrem of the regulator.

or

b) i) in the excluder outfall or at the exit of excluder tunnels, and
   ii) in the canal downstream of the regulator.

In the first case under (a) the percentage efficiency of the sediment excluder is worked out from:

$$\text{Percentage efficiency} = [(I_f - I_c) / I_f] \times 100 \qquad \dots \text{(i)}$$

where

I_c = silt intensity in parts per thousand parts of water by volume in the canal, downstrem of the canal regulator; and

I_f = silt intensity in parts per thousand parts of water by volume in river pocket.

6.3.1 Generally, it is not possible to take samples of suspended silt in the river pocket. In that case, the intensity of silt in the flume or river pocket is calculated from set of observations mentioned under (b) of **6.3.**

$$I_f = \frac{Q_c I_c + Q_E I_E}{Q_c + Q_E}$$

where

I_E = silt intensity in the excluder,

Q_C = discharge in the canal, and

Q_E = discharge in the excluder.

From the value of I_f thus obtained, the efficiency is worked out as in (i).

6.3.2 The efficiency of an excluder varies with river stages. It remains more or less constant so long as conditions of flow, slope and approach to the excluder do not materially change. Suitable river regulation has to be adopted to secure proper approach condition for the excluder.

6.3.3 *Typical Design*

Design procedure using sediment transport concept is given in Annex A.

7 STRUCTURAL DESIGN

7.1 For the structural design of sediment excluders, load due to water of the pond and load due to the silt deposited inside and outside of the tunnel should be considered.

7.2 The silt excluder has to be checked for floating and sliding also with no silt load on top of the tunnels.

7.3 A trash rack may be provided at the inlet of tunnel to avoid entry of trees and big branches in the tunnels. A provision of jetting water or compressed air in the tunnels may also be made for convenience of flushing of consolidated sediment deposit in the tunnels.

ANNEX A

(*Clauses* 4 *and* 6.3.3)

A-1 The following data relating to the canal and barrage are needed for design of sediment excluder:

a) Site plan.

b) Data for existing river near the head regulator:

   i) contour plan,

   ii) cross-sections,

   iii) stage discharge curve and the hydrograph of the river at the outfall, and

   iv) sediment data.

c) A contour plan of the area around the proposed site of the weir or barrage with contour intervals of not more than 0·5 m, up to an elevation of at least 2·5 m above the high flood level. The contour plan shall extend to about 5 km on the upstream and downstream of the proposed site and up to an adequate distance on both flanks up to which the effect of pond is likely to extend.

d) Plan showing barrage and head regulator and cross sections of undersluice bays and head regulator showing all levels and dimensions, design discharge, pond level, H.F.L. and super flood discharge, if any used in barrage design are to be furnished.

Design of tunnel-type sediment excluders using sediment transport concepts.

1. Choose maximum river discharge for which pond level is maintained.

2. Compute bed shear stress $\tau = \gamma Ds$ or γ_{rs}.

where

D = mean depth at flow,

r = hydraulic mean radius of flow,

s = slope of river, and

γ = specific weight of water.

3. Determine the size of the coarsest material (d_s) which will move at this stage, d_s by shields or white criterion where d_s = size of coarsest material.

4. Assume some value of tex (tex = tunnel depth), between 1 to 2 m and determine critical velocity V_c for size of material as computed in step (3) from equation:

$$\frac{V_c}{\sqrt{\frac{\Delta \gamma_s}{\rho} d_s}} = 1{\cdot}6 \left(\frac{r_{ex}}{ds} \right)^{1/8}$$

where

$\Delta \gamma_s = \gamma_s - \gamma$

γ_s = specific weight of sediment, d_s = sediment dia, t_{ex} = tunnel depth, r_{ex} = hydraulic mean radius of tunnel, ρ = Density of water, and γ = specific wieght of water.

5. Decide the required velocity through the tunnels for transporting the sediment as per the criteria given in **5.5.1** and **5.5.2**.

6. Select excluder velocity $V_{ex} > V_c = V_L$.

7. Find b_{ex} = equal to width of one, two or three undersluice bays where b_{ex} = width of excluder bays.

8. From the correlation $b_{re} = \frac{Q_c + Q_{ex}}{q_r}$ compute river width contributing discharge to the undersluice pocket. Above equation is given as a general guideline. Actual b_{re} may be assessed from observations in the model. Here b_{re} is the width of river contributing canal and excluder discharge in the pocket:

where

q_r = intensity of discharge of river,

Q_c = canal discharge in cumecs, and

Q_{ex} = excluder discharge in cumecs.

9. From the actually measured value of bed load per meter width of river at site or from the formula such as Meyer Peter and Muller, Einstein's, etc, find out bed load coming into the tunnels for river width b, which is required to be excluded by excluders.

10. From actual observations determine suspended load in the river per metre width of the river. Next determine portion of suspended load going in the pocket for equivalent river width b_{re} (b_{re} = river width contributing discharge to the undersluice pocket). Compute sediment concentration C in the excluder tunnel, which is required to pass down to river channel by adding bed load and suspended load as in step 9 and 10.

11. From the pond level maintained, available head is known and assuming length of tunnel to be equal to that from start of head regulator to the crest of undersluice, compute $\left(\frac{\Delta h}{\Delta L} \right)_m$ in m, the head loss per unit length of the tunnel for the sediment water mixture.

12. Using equation after Durand-Condolios,

namely, $$\frac{\left(\frac{\Delta h}{\Delta L} \right)_m - \left(\frac{\Delta h}{\Delta L} \right)_L}{C_T \left(\frac{\Delta h}{\Delta L} \right)_L} = 180 \left(\frac{V_{ex}^2}{g\, r_{ex}} \sqrt{\frac{g\, d_s}{w^2}} \right)^{-3/2}$$

compute concentration of sediment C_T which can be transported by excluder tunnels, where V_{ex} = velocity in tunnel, d_s = size of bed materials, r_{ex} = hydraulic means radius of tunnels, $\left(\frac{\Delta h}{\Delta L} \right)_L$ = head loss of only water, that is, $\frac{f\, V_{ex}^2}{8g\, r_{ex}^2}$ where $f = 0{\cdot}012$, w = fall velocity of bed material of size (d_s), specific weight of sand particle = 2·65.

13. The C_T as obtained in step 12 should also be checked by the use of equation:

$$R_e \sqrt{f} = \left(\frac{I}{d_s/4\, r_{ex}} \right)^{S_1} C_T^{1/3}$$

where

S_1 = 0·89 d_s with d_s in mm,

C_T = average concentration in percentage by weight,

R_e = Reynold's number in tunnels, and

f = Darcy Weisbach friction factor.

Where I has the following values for different values of d_s as given below by Grade:

d_s (mm)	0·100	0·20	0·6	0·9	1·5	2·5
I	0·065	0·42	9·0	50·0	460·0	550·0

If concentration computed in steps (12) and (13) is greater than C_{ex} (step 10) it is all right. Repeat the above step from (4) to (13) for different values of tex (1·0 to 2·0 m), Q_{ex} (10 to 20%) Q_c and b_{ex} and choose the best combination. (The one with which blockage is minimum, Q_{ex} is minimum, entire concentration is transported with fair margin of safety.) Having so fixed the over all dimensions, the hydraulic design be next carried out for number of tunnels, entrance, etc.

14. Hydraulic losses in tunnels.

These shall comprise friction losses and those due to bends and transitions in contractions or expansions loss due to sediment laden water and shall be evaluated or given.

15. Loss due to Bellmouth at entrance.

It shall be obtained by the following formula:

$$h_{bm} = K \left(\frac{V_2^2}{2g} \right) - \left(\frac{V_1^2}{2g} \right)$$

h_{bm} = head loss due to Bellmouth

k = 0·5 for sudden contraction and 0·05 for bellmouth from all sides

V_2 = velocity in tunnel

V_1 = velocity at entrance

16. Friction losses — These shall be computed by the following formula:

$$h_f = \frac{V_2^2 Ln}{r_{ex}^{4/3}}$$

where

h_f = head loss in m, in tunnel,

V_2 = average velocity in m/s in tunnel.

L = length of tunnel in m,

n = rugosity coefficient of the tunnel surface, and

r_{ex} = hydraulic mean radius in m of tunnel.

17. Values of rugosity coefficient (n) for various surface shall be taken in accordance with IS 10430 : 1982.

18. Contraction losses — It shall be obtained by the following formula:

$$h_c = 0{\cdot}1 \left(\frac{V_3^2}{2g} - \frac{V_2^2}{2g} \right)$$

where

h_c = head loss due to contraction;

V_3 = average velocity at the exit of transition in m/s;

V_2 = average velocity at the entrance of transition in m/s, that is, velocity in tunnel; and

g = acceleration due to gravity in m/s^2.

19. Loss due to bend

$$h_b = F \left(\frac{V_2^2}{2g} \right) \frac{\theta}{180}$$

and $F = 0{\cdot}124 + 3{\cdot}106 \,(b/_2 \, R)^{1/2}$

where

b = width of tunnel,

R = radius of bend along centre line of tunnel, and

θ = angle of bend.

Notations

b = width of tunnel

b_{ex} = width of excluder bays

b_{re} = width of the river contributing canal and excluder discharge in the pocket

C_v = average concentration of sediment in percentage by weight

d = mean depth of flow q/d

d_s = size of coarsest material in mm

D = Depth of flow

f = Darcy-Weisbach friction factor

g = acceleration due to gravity

h_{bm} = head loss due to Bellmouth

h_c = head loss due to contraction

h_f, H_f = head loss in m in tunnel

I_c = silt intensity in parts per thousand parts of water by volume in the canal downstream of the canal regulator

I_E = silt intensity in the excluder

I_r = silt intensity in parts per thousand parts of water by volume in the river pocket

L = length of tunnel in m

n = rugosity coefficient of the tunnel surface

Q_c = canal discharge in cumecs

Q_E or Q_{ex} = excluder discharge in cumecs

q_r = intensity of discharge of river

r = hydraulic mean radius of river cross-section

R = radius of tunnel along centre line of tunnel

R_e = Reynold's number in tunnel using kinetic viscosity of clear water

r_{ex} = hydraulic mean radius of tunnel

S = slope of river

S_1 = numerical constant = 0·89 ds

t_{ex} = tunnel depth

V_c = critical velocity in m/s

V_1 = velocity at entrance

V_2 = average velocity in m/s in tunnel

V_3 = average velocity in m/s at the exit

V = fall velocity of bed material of size ds

$(\Delta h/\Delta L)_L$ = head loss due to water Q/L

$(\Delta h/\Delta L)_m$ = head loss due to sediment laden water q/s

ρ = density of fluid (water)

ρ_s = density of sediment

γ_s = specific weight of sediment

γ = specific weight of water

τ_c = bed shear stress

θ = angle of bend

V_{ex} = velocity in tunnels

V_L = limit deposit velocity in m/s

(Continued from second cover)

Silt excluders are required to be provided in the river pockets of weir/barrages when river characteristics predominantly occur as given below:

a) When there is high ponding upstream of the barrage to meet the canal discharge requirements;

b) When the river/tributary is bringing sediment load of the order of 1 500 ppm and above, and contains significant percentage of coarse and medium sediment;

c) If the river is in aggrading stage or wherever formation of bed bars/shoals is noticed due to unfavourable approach condition;

d) Bed building stage of the river may occur due to barrage obstruction to flow as well as improper regulation on the barrage gates;

e) Due to adverse flow curvature upstream of the barrage head regulator, most of sediment load in high river stage may likely to settle in front of the head regulator and may enter its way in the canal;

f) Inspite of suitable location of head regulator, river training measures for arriving favourable curvature of flow, providing divide walls for separating pockets from barrage bays and suitable gate regulation of barrages/undersluice bays for sand exclusion, a large quantity of coarse material may find its way into the pocket. In such cases for efficient working of canal, silt excluders are required to be provided in the pocket; and

g) Exclusion of gravels and boulders could be achieved by providing barrage crest at river bed level and ponding operation only during non flood season. Similarly, features such as frontal intake, provision of river sluices, undersluices with lower crest, provision of divide walls — their orientation and lengths, barrage gate regulation are some of the features depending upon sediment load and hydrograph characteristics of river as well as cut off available and pond level to be maintained. Generally, gravels and boulders are excluded by keeping crest of weir low and suspended load, bed load is excluded through tunnel where 1 m cut off is atleast available.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the results of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Standard Mark

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Revision of Indian Standards

Indian Standards are reviewed periodically and revised, when necessary and amendments, if any, are issued from time to time. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition. Comments on this Indian Standard may be sent to BIS giving the following reference:

Doc : No. RVD 20 (0021)

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 331 01 31, 331 13 75

Telegrams : Manaksanstha
(Common to all offices)

Regional Offices :	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	331 01 31 331 13 75
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola CALCUTTA 700054	37 84 99, 37 85 61 37 86 26, 37 86 62
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	53 38 43, 53 16 40 53 23 84
Southern : C. I. T. Campus, IV Cross Road, MADRAS 600113	235 02 16, 235 04 42 235 15 19, 235 23 15
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) BOMBAY 400093	632 92 95, 632 78 58 632 78 91, 632 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. PATNA. THIRUVANANTHAPURAM.

Printed at New India Printing Press, Khurja, India